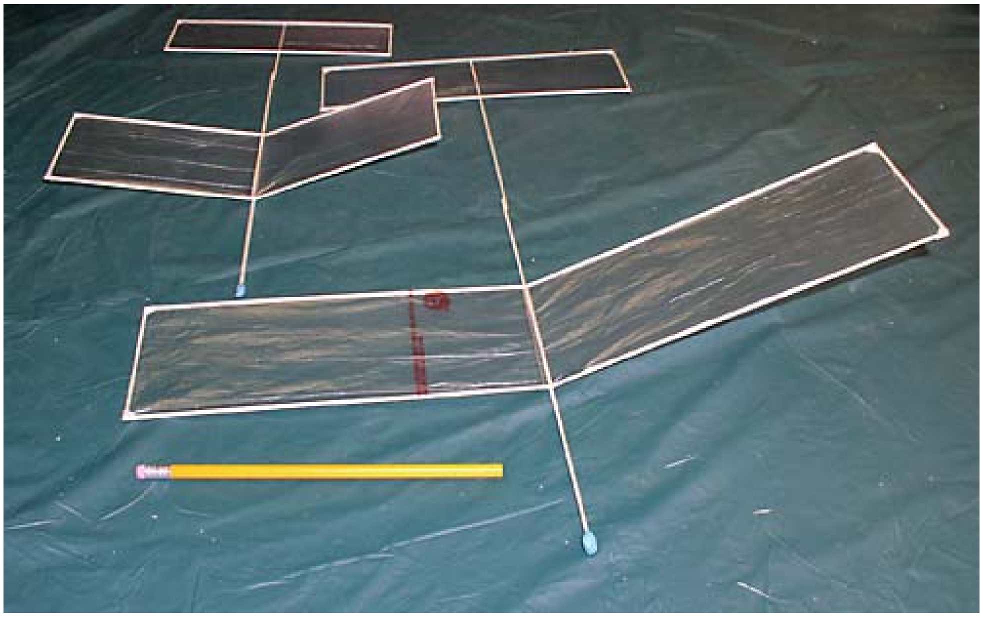
The Kisloon Glider

By Chuck Markos and Tim Gebhardt



Two Kisloon Gliders, 28 cm wing and 47 cm wing

Introduction

This glider was developed to fill a need observed by the author from his experience with the Science Olympiad Balloon Launched Glider as the event supervisor at the Illinois state finals competition as well as at regional competitions over two years since the event has been in existence. The great majority of the models brought to the competitions simply did not fly. Aerodynamic faults of construction integrity, overweight structure, mis-alignment of flying surfaces and improper balance contributed to their failures. Most of these faults could have been easily fixed. I have helped many a competitor in practice sessions to correct such faults to transform a seemingly hopeless glider into a well-behaved one in a matter of minutes. To test the viability of this glider, a clinic was held on the evening before the 2007 state competition at the University of Illinois ROTC armory. Seven teams showed up to construct and fly the glider. The seven models were completed in less than one hour and test flown to times greater than 90 seconds in the armory under its 95-foot ceiling. That performance was better than 30 of the 43 teams who competed the next day.

The basic construction technique for this glider follows from that of a well-known beginner's model, the Delta Dart, also known as the AMA Cub. The glider is built directly on the covering by gluing sticks of wood to transparent plastic covering placed over the plans. The paper gussets at the wing and stabilizer corners are from the technology used on the Delta Dart. One notable feature of this glider is the absence of a vertical fin . It was left off to make construction as simple as possible. Flight testing indicated that a fin was not necessary for stability, but may be of service to help control the glide circle. The glider will fly in a circular pattern because of small warps that occur during construction of the wing and stabilizer. Some earlier developmental designs were built using tissue paper (wrapping paper) and a glue stick to attach the balsawood strips, but were a bit overweight. Use of a glue stick for plastic covering is not recommended as the covering will not be permanently attached to the wood.

One of the seemingly immutable laws of competition model aircraft is that the more times the same model is built by the same person the better it gets . This holds for so-called experts as well as rank beginners. One attraction of this glider is that the material expense is so minimal that literally dozens can be built once the balsawood and adhesives are in hand. A more important consideration, however, is that the student has the opportunity to gain some learning through experimentation. For example, design parameters to arrive at a glider within the mass specification (currently no less than 2 grams) can be investigated by weighing its component parts before construction and deciding where mass can be reduced and where it should not be reduced from the results of the previous glider. A second avenue of scientific investigation is in the optimization of flight by changes in mass distribution, flight path, and modes of launch from resting on the balloon to free flight. If the student has more than one glider, differences in their performance characteristics offer opportunities for investigations on a scientific nature. The mandatory flight log for the event encourages such investigations. However, just keeping a bare flight log will not be sufficient. The student should be encouraged to make each flight an experiment by intentionally changing some aspect of the model or the launch method.

The two most critical mistakes that I have observed are that students:

Do not pay attention to the balance point (also known as the center of gravity) of the model (it's shown on the plan)

There is no angular difference between the wing and the stabilizer

If the wing trailing and leading edges are on the (presumably) straight fuselage, the trailing edge of the stabilizer must be a little higher than its leading edge when the tailboom is attached to the fuselage. If the student wants to design his own airplane, the proper center of gravity can be calculated from an internet site: http://adamone.rchomepage.com/cg_calc.htm. You can also find the site by typing "aircraft center of gravity" into your favorite search engine. Once the center of gravity is set, only very small changes should be made to adjust the flight.

Construction of this glider will take about one hour. Make sure you have all the parts, adhesives and tools ready before you start

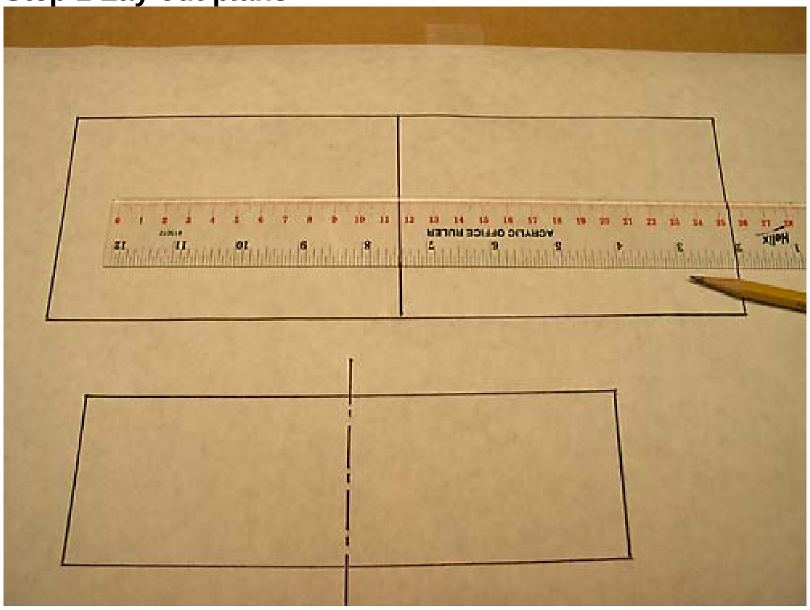
Index

Materials

The links in this list are direct links to the items as listed on Amazon.com.

- Balsawood 1/16" sq, 1/8" x 1/16" (see note 1 under step 3)
- Metal straight edge
- Weldwood Non-Flammable Contact Cement
- Container to mix the contact cement with water
- Super Glue (Loctite brand) (brush-on bottle is best)
- 5-minute epoxy glue
- Toothpick for mixing epoxy glue
- Glue stick
- Common straight pins (4)
- Corrugated cardboard (2 sheets bigger than the plans)
- Single-edged razor blade
- X-acto knife with No 11 blade (optional)
- Plastic bag from produce supplies at grocery store (the lighter the better) (do not use household plastic wrap...it is much too heavy)
- Foam from meat tray or egg carton for spreading glue
- Felt tipped pen
- Modeling clay
- Scissors
- A box to store and carry your model. This one fits into a copier paper supply box
- Fiber reinforced strapping tape
- Masking tape
- Nylon fishing line (10 - 12 pound test)
- Helium-filled 24-inch plastic balloon
- Helium tank
- Fishing reel with line

Step 1 Lay out plans



Kisloon glider plans

A reduced-size plan is attached to these instructions. Since the size of the Science Olympiad airplanes are changed from year to year, you may want to change the size of the model to suit the current specifications. All that is necessary is to draw two rectangles, one for the stabilizer and one for the wing (with a line bisecting the wing at the center for the center rib). Make sure that the centerline of the stabilizer is indicated by a dotted line. Wood thicknesses remain the same...only the lengths are changed to fit the new plans.

Notes about provided glider plans

You can get a copy of the plans by clicking this link.
To convert the Kisloon to the Kisline towline glider click here for instructions.
When printing the plans make sure to set "Page Scaling" to "None" in order for the gussets to print to scale.

Step 2 Obtain a box

Find, buy or make a box big enough to hold your finished model. The 28 cm winged glider fits into a copier paper box.

Step 3 Cut balsa wood

Balsa wood pieces arranged by length

For the glider as shown on the plans cut 1/16” square balsa to the following lengths: 28 cm (wing spars, 2 required), 9 cm (wing ribs, 3 required), 20 cm (stabilizer spars, 2 required), 6 cm (stabilizer ribs, 2 required) and 11 cm (tailboom). Place the three wing ribs side by side to make sure they are of equal lengths, exactly...same for the stabilizer ribs. Mark a few “dots” on one surface of each piece so you can make sure the glue is applied to only that marked surface in step 6 below. Use a felt-tipped pen to mark the dots. The wood for this model (including the fuselage stick...step 14) should not weigh more than one gram. Note that the dimensions of the glider are defined by the pre-cut wood lengths. As such, the only function of the plan drawing is to make sure the corners are square.

Notes:

1. Most balsawood sticks you can buy are quite heavy wood. To keep your glider lightweight it is best to buy a sheet of 1/16” balsa and strip the wood using a metal straight-edge and a razor blade: Hold the metal straight edge firmly on the wood while a sharp blade is drawn next the straight edge (see note 3 below). A sheet of 1/16 x 3 x 36 should weigh no more than 12 - 14 grams. The weight of the wood for this glider can vary from as little as 0.7 grams to more than 2 grams depending on the density of the wood selected. Light is better than heavy. Appropriate density of the balsawood should be in the range of 0.15 to 0.20 grams per cubic cm. Use the heavier, stronger wood for the fuselage. The lightest wood should be for the shortest pieces...the ribs for the wing and stabilizer. Most balsa wood of 1/16” nominal thickness ranges from 0.65” to 0.70” in thickness. Conversion to metric units is therefore about 0.15 cm for thickness. Since balsawood is sold in sheets and sticks that are measured using inches, strict adherence to the metric system will require some conversion factors.

2. Balsawood sheets are not of uniform density. Holding a sheet of balsawood up to a light source will illustrate areas that are more dense (darker) and less dense (lighter). Use the more dense wood where greater strength is required.

3. Most novices find that a hobby knife (X-acto) with a number 11 blade is easier to use than a razor blade for stripping balsawood. The problem with a razor blade is that beginners find it difficult to hold the blade vertical while cutting. However, hobby knife blades are not as sharp as razor blades. The stripping technique will require several cuts

along the firmly held metal straight edge until the cuts completely remove the strip. If a single cut is forced by pressing the blade, the wood strip will often be distorted.

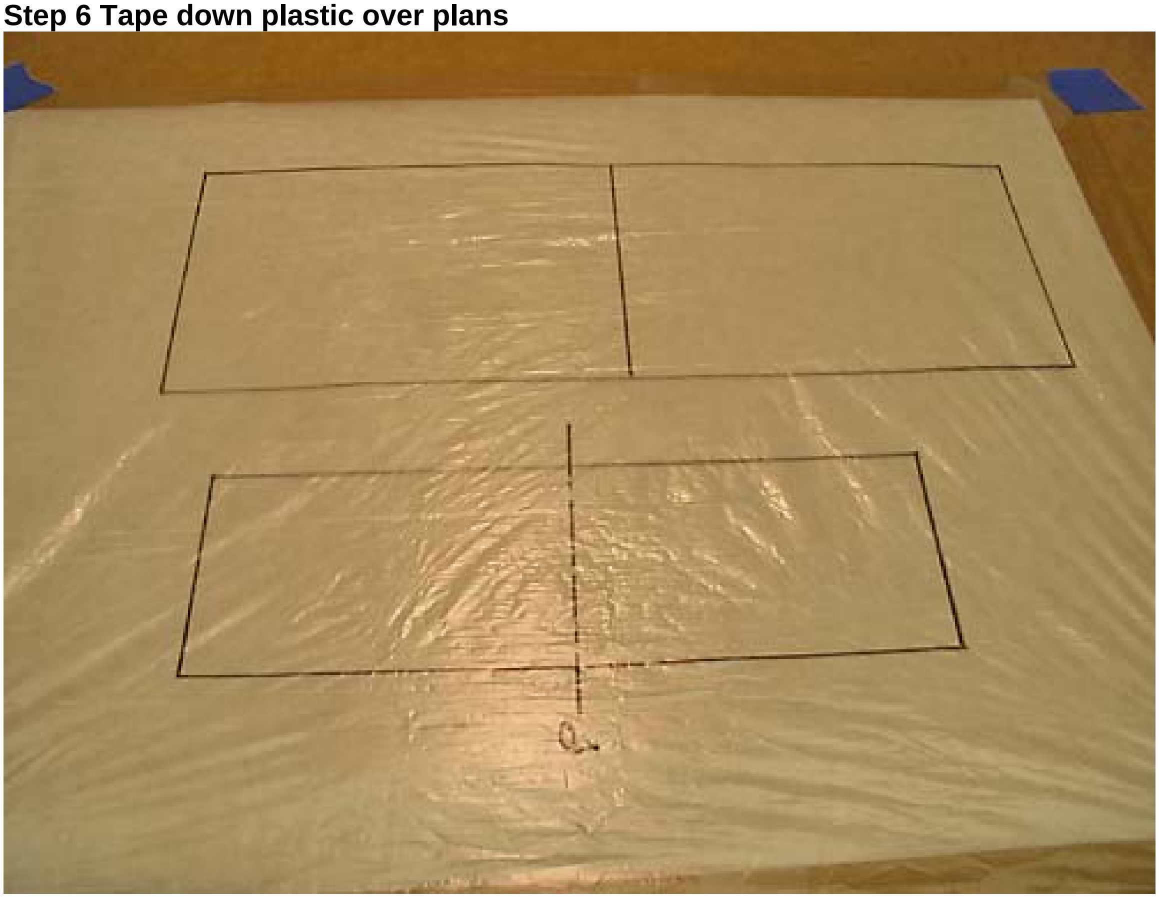
It is not important that all strips of wood are exactly the same width, but it is important that each strip is consistent in its width. Place cardboard or poster board under the balsa to protect your work surface. Start by cutting the 36-inch sheet to the longest length required for construction, 31 cm.

4. Instruction step 3 lists lengths of balsa wood that are specific for the glider shown on the plans. If the glider is re-designed to a different size, then the lengths will be different. Suggested lengths for a glider for the 2008 competition rules are: Wing spars (four @ 23.5 cm), wing ribs (three @ 9 cm), stabilizer spars (two @ 26 cm), stabilizer ribs (two @ 7 cm) and tailboom (one @ 24 cm). The fuselage stick remains the same, 31 cm.

Step 4 Remove the gussets from the plans
Cut out the section (dotted line) showing full-sized paper gusset and fin pattern from the plans.

Step 5 Tape plans to cardboard
Tape the plans to a piece of cardboard (two thicknesses of cardboard are recommended so that pins pushed in will hold).

Step 6 Tape down plastic over plans



Plastic taped down over plans

Plastic produce bag from grocery store

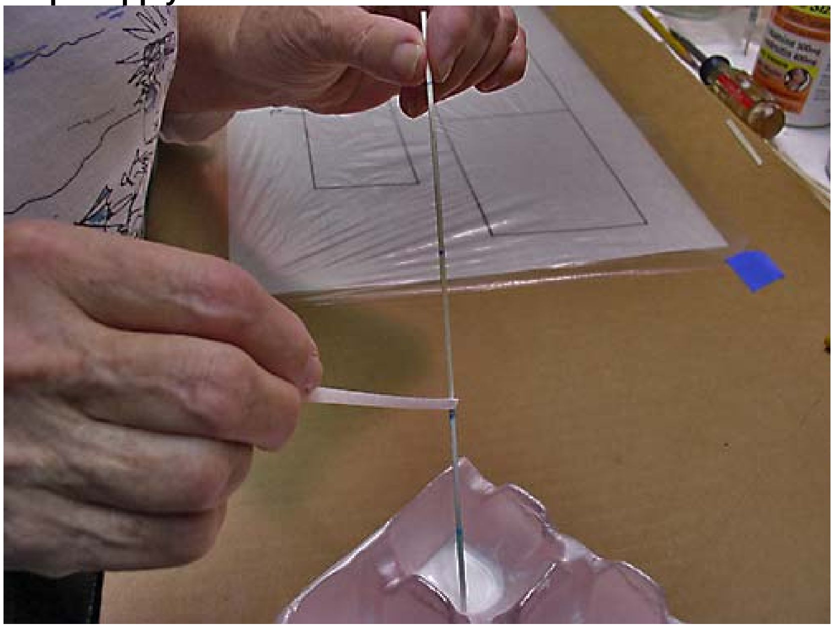
Tape thin plastic over the plans.
This plastic will become the covering for the glider when it is finished. It is not used to protect the plans as is often the case. You can also hold the plastic in place with pins at each corner. The covering for this model is from a grocery store produce bag. Look for the HDPE logo on the bag. The bag should weigh about 2 grams for a 16.5” x 12” size. Split the bag and use only one sheet of plastic. The covering will add about 0.25 grams to the total mass of the 28 cm wing glider and about 0.5 grams to the 47 cm glider.

Step 7 Mix water-based contact cement with water

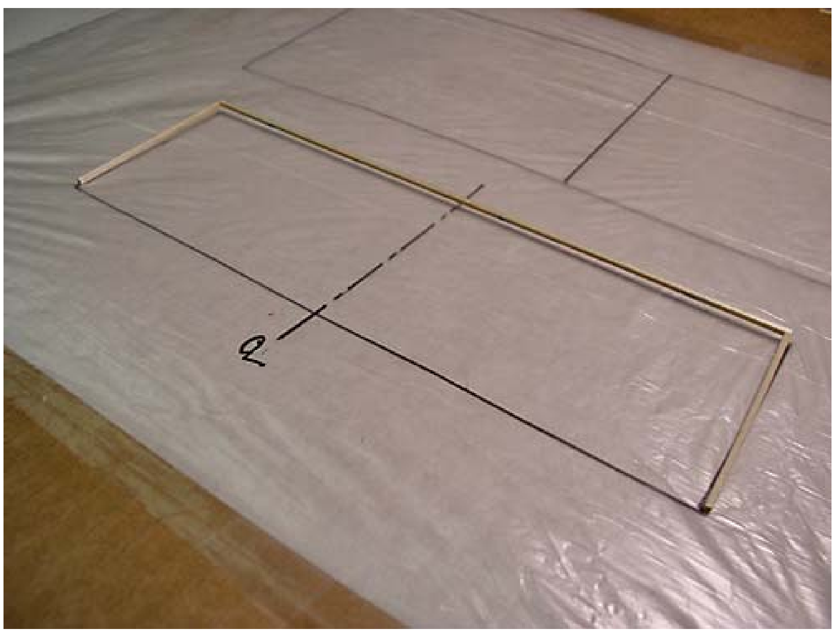
Recommended brand of water-based contact cement

Mix some water-based contact cement about 50/50 with water to make it thinner. Contact cement can be very messy to work with. It cannot be completely removed from most surfaces. It comes in a rim-sealed paint can. Very little cement is needed to complete the model. To avoid filling the rim of the can with cement, remove some cement from the can with a scrap of polystyrene and place it in a container (egg carton shown). Mix in a little water and discard the scrap polystyrene.

Step 8 Apply cement to stabilizer



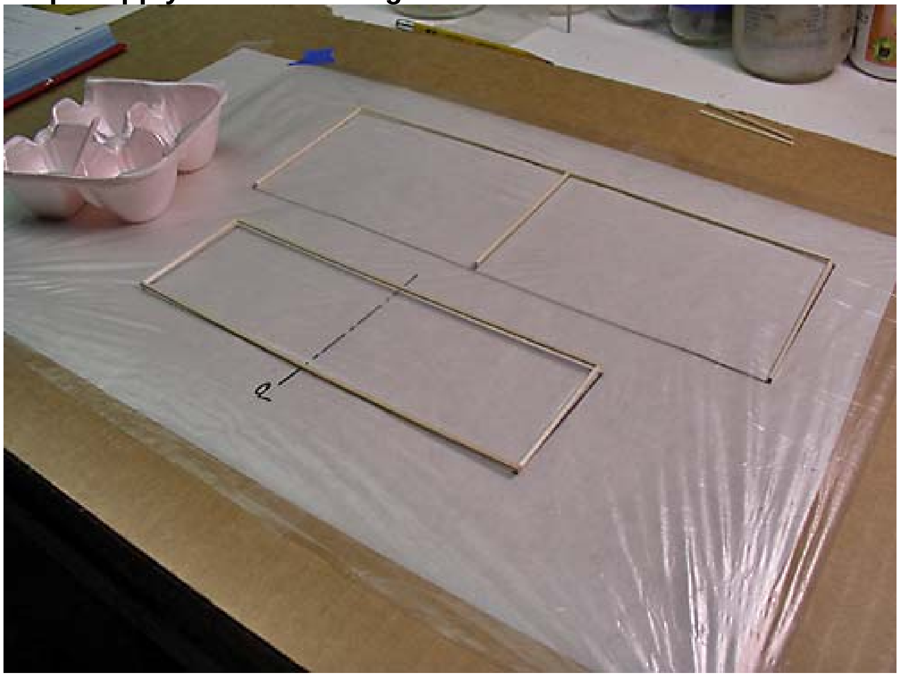
Applying the cement to the balsa wood



Stabilizer glued to plastic

Use a thin scrap (about 0.5 by 7 cm) of polystyrene plastic (from a grocery store meat tray or egg carton) as glue applicator. Apply the thinned contact cement to one surface of a stabilizer spar (make sure there are no gaps) and immediately place it on the plastic covering the plan where the stabilizer is shown. Add the two stabilizer ribs at the ends (no rib in the center) the same way and finally the second spar so there is no gap between the spars and the ribs. Scraps of polystyrene are used instead of a brush to apply the contact cement because it will be impossible to clean the brush after it has been used with the cement.

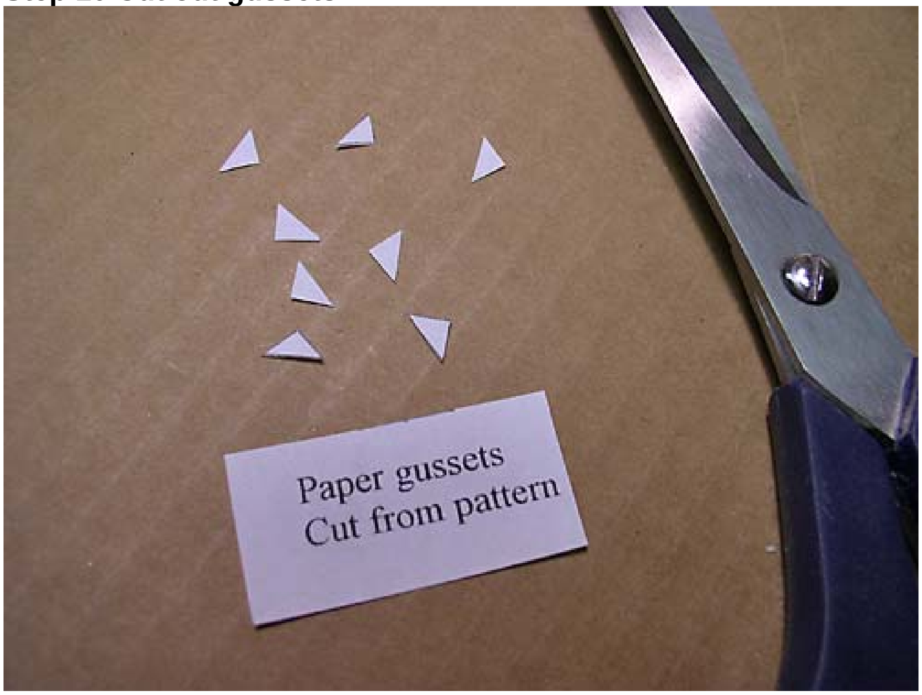
Step 9 Apply cement to wing



Stabilizer and wing glued to plastic

Construct the wing in the same manner as the stabilizer: First one spar, then three ribs and last the second spar. In a few minutes, the glue will form a bond between the covering and the wood. If the wood curls a bit and separates from the covering, just push it down gently until it stays put. For the 47 cm wing glider, the leading edge and trailing edge spars are in four equal lengths, joined at the center, but not glued together.

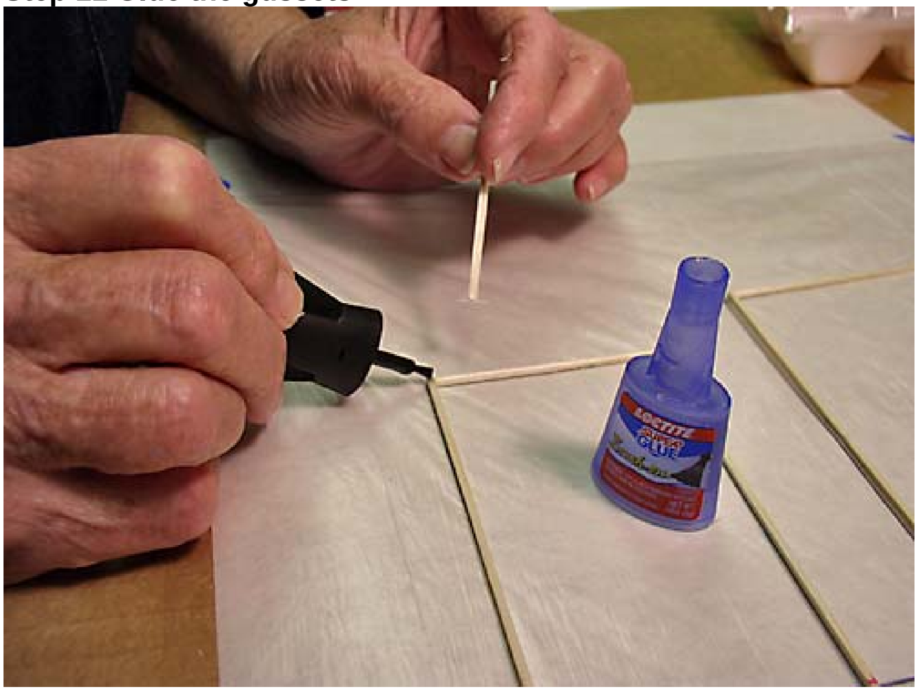
Step 10 Cut out gussets



Paper gussets from pattern

Cut out the eight small triangles from the paper gusset pattern. Put them in a safe place so they do not get lost. It is not absolutely necessary to use the provided pattern. Just cut out four squares of paper, 0.6 cm (actually 1/4") on a side and then cut each one on the diagonal to provide two triangles.

Step 11 Glue the gussets



Gluing the gussets

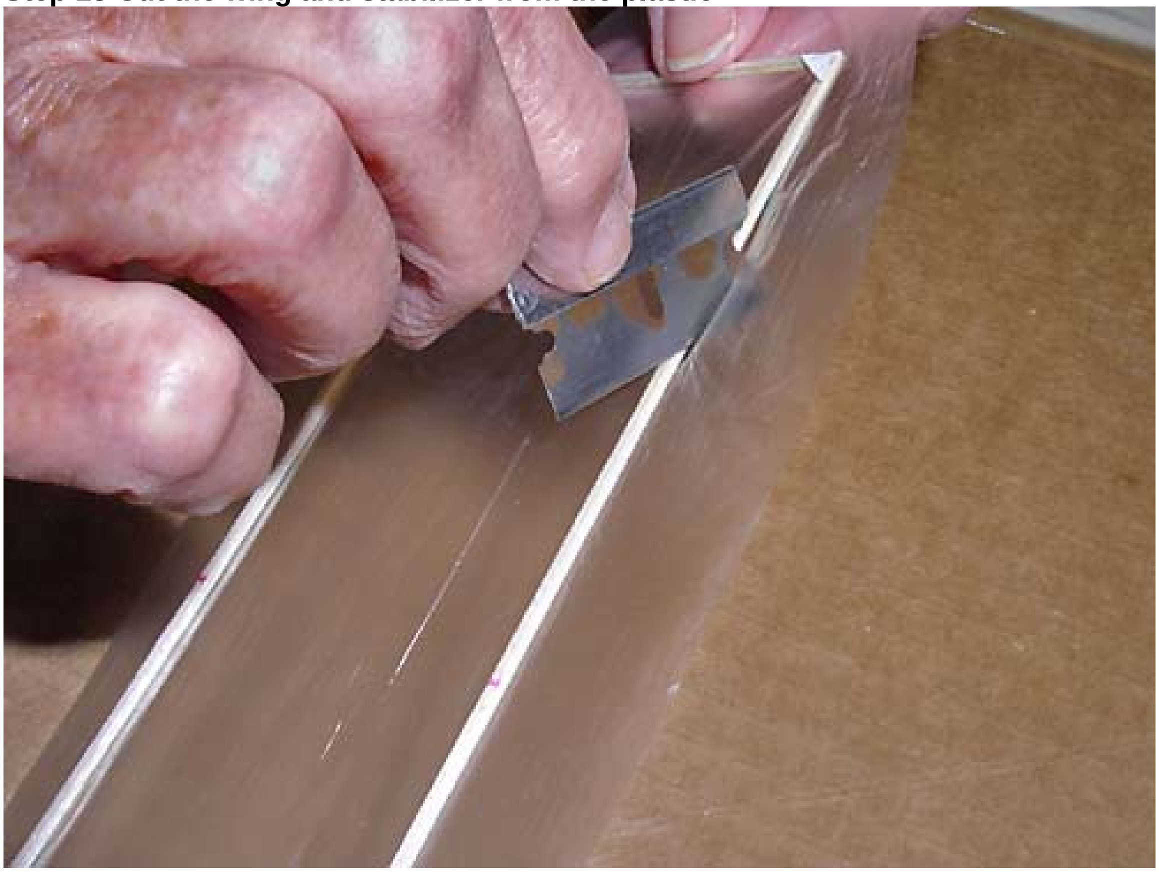
Use the end of a scrap of balsa wetted with saliva (just touch the end of the stick to your tongue) to pick up and place a paper gusset. Brush a small amount of Super Glue into a corner and quickly place the paper gusset on the glue. The glue will set up in a few seconds. If you wait too long to place the gusset on the glue, it will not stick to the paper. The brush-on Super Glue is the only brand that is compatible with those of limited building skills. Other types may result in large excess of glue being used, spills and fingers being stuck together.

Step 12 Glue the rest of the gussets

Recommended glue for gluing the gussets

Repeat step 11 until all the corners of the stabilizer and wing have gussets in place. There are no gussets at the center of the wing. Mark the stabilizer’s spars at the center line shown on the plans. The stabilizer will be glued to the tailboom at those marks.

Step 13 Cut the wing and stabilizer from the plastic



Cutting the wing and stabilizer from the plastic

Cut out the wing and stabilizer from the covering plastic: First make a rough cut to leave about 2-5 cm excess around each. Pick up the structure and finish the trimming of the excess covering with a sharp (new) single edged razor blade. Use the corner of the blade. Move your holding hand frequently so that it is always close to the blade. Always cut away from the hand holding the piece. Start the cut in the middle and work towards the ends. Keep the uncovered wood side facing your eyes.

Step 14 Prepare the fuselage

The fuselage stick is prepared from 1/8” x 1/16” balsa, 31 cm in length. If you have very soft balsa, the stick can be 1/4” by 1/16”. Make a mark on the fuselage 11 cm from the front. The tailboom is 1/16” square, 11 cm in length.

Step 15 Attach stabilizer to the tailboom

Stabilizer attached to tailboom

Use the brush-on Super Glue to attach the stabilizer to the tailboom at the center line marks on the wood of the stabilizer.

Step 16 Prepare wing dihedral angle

To form the wing dihedral angle, cut part way (less than half) through the wing spars at the location of the center rib. Crack the spars so that the wing bends at the center rib. Take care that the spars are not completely broken away. For the 47 cm wing, the two halves are already cut through.

Step 17 Create the wing dihedral

A tent-like fold in the wings

Make a tent-like fold in the wing with the covered side down on the cardboard by placing pins through the paper gussets at the four corners of the wing tips. The center should be elevated by 3-4 cm.

Step 18 Glue the fuselage to the wing

Mixing epoxy

Put a gob of mixed 5-minute epoxy glue on the two wing spars where they were cracked and place the fuselage onto the glue with the narrow part of the fuselage into the glue. One of the glue joints should be at the 11 cm mark you made on the fuselage. When the glue is completely cured (15-20 minutes) remove the pins holding the wing tips.

Note:

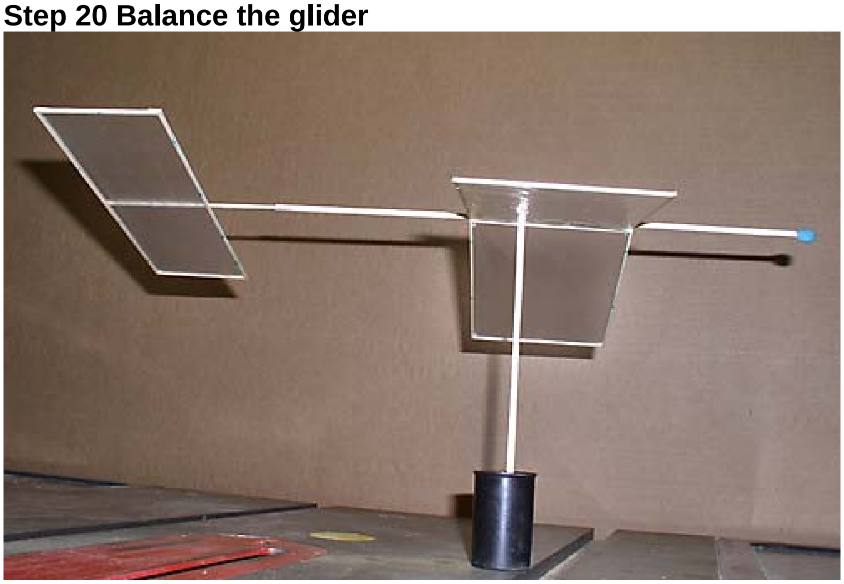
Be careful to measure approximately equal amounts of the epoxy resin and hardener on a non-porous surface (use a portion of your polystyrene egg carton). Stir the two parts thoroughly. If the glue is not thoroughly mixed, it will not harden properly. A common cause of incomplete mixing for small quantities is that the mixture of resin and hardener on the mixing stick are either not mixed or that they are in unequal proportions. About halfway through the mixing process, the mixing stick should be wiped off onto the mixing surface. Recombine the portion that was wiped off with the mixed puddle remaining on the mixing surface. Epoxy glue is used for this connection because it will fill the gaps left by cracking the wing above and also the gap where the angled wing parts are not in contact with the fuselage. Wait at least 15-20 minutes before picking up the assembly. Otherwise the epoxy will not harden sufficiently to keep the angles as they had been set. Freshly mixed epoxy is quite fluid and the fuselage stick will tend to fall over. The best technique is to place the fuselage onto the wet epoxied joint then remove it and set it aside until testing the excess shows it to become thick. Replace the fuselage on the thickening epoxy and it will stay where it is put.

Step 19 Attach stabilizer and tailboom to fuselage

Notice the slight up-angle

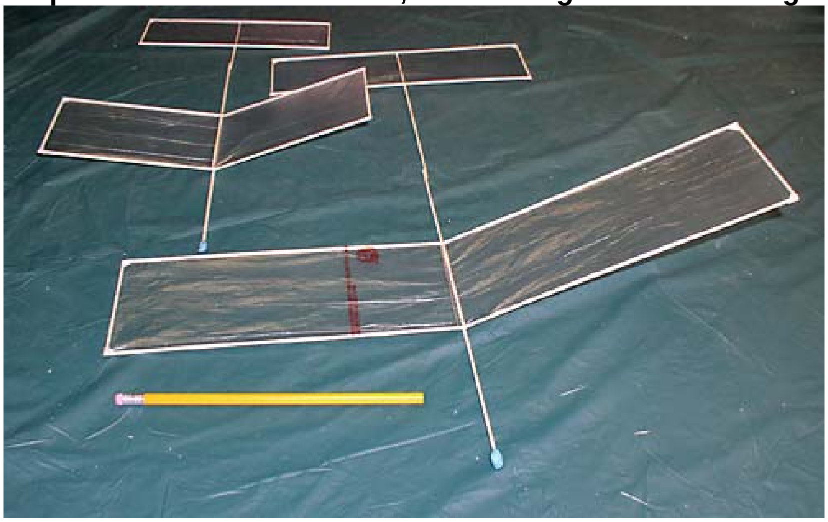
Glue the tailboom and stabilizer assembly to one side of the fuselage with a slight “up” angle to the tailboom. Use Super Glue. The stabilizer covering should be topside.

Step 20 Balance the glider



Balance the glider at the position shown on the plans by adding clay to the front of the glider (fuselage nose).

Step 21 Two Kisloon Gliders, 28 cm wing and 47 cm wing


Two completed gliders: 29 cm wing and 47 cm wing.

Step 22 Testing the glider
Test fly the glider for a smooth flight. Release it very gently, do not throw the glider unless you want to break it. Adjust the glide by adding or removing clay.

Step 23 Adjust glider flight
If the glider needs adjustment of the flight path circle, cut out the paper fin and glue it to the fuselage in front of the stabilizer. Use a glue stick. The circle can be adjusted by bending the aft portion of the paper fin. The fin may also be glued near to the nose of the glider. Doing so will keep the glider lighter in weight because some clay can be removed from the nose to compensate for the weight of the paper fin.

Flying the balloon launched glider
The balloon-launch rig starts with a 24-inch plastic balloon filled with helium from your local party store. A yoke is constructed from fishing line taped to the perimeter of the balloon at three equally spaced points. Tie a loop in the fishing line to make sure it is not easily dislodged from the tape. Use fiber-reinforced tape. Hold all three lengths of line between your thumb and forefinger and adjust their lengths until the balloon is level. Tie a knot at that point. Attach the yoke to a second line on a fishing reel. To keep the model from prematurely flying off the balloon surface, a ring of paper about 30 cm in diameter and 3-4 cm wide is taped to top of the balloon. It takes some practice to raise the balloon and glider smoothly to maximum altitude. Jerky stop-and-go raises should be avoided. One member of the team advises the balloon raiser when to stop raising the balloon and release the model into free flight. Extra helium for re-fills and top-ups can be purchased from party supply stores or from Wal-Mart.

The room in which you fly the glider should be free of all drafts. If it is a school gym, ask the school custodian to turn off the HVAC fans for the duration of your testing. Close any access doors to hallways to avoid spill-over drafts. Super light-weight gliders will be tossed around by the HVAC as though they were in a violent storm. No useable information will come from testing in such conditions.

The longest flights are obtained removing nose weight until the glider has just a slight stall, then adding just enough weight back to the nose to give a smooth flight path. A smooth flight path indicates that the airplane is in "trim." A second consideration is that the flight circle should be as wide as the room will allow without hitting the walls. A good rule of thumb is that the flight path circle diameter should be about 1/3 of the shortest dimension of the room. The adjustments mentioned in this paragraph are best made by hand-gliding the model. Some practice is necessary to get a smooth release. That is, the release should be with the same speed that the glider wants to fly and also at the same attitude (nose down just a bit). If you release too slowly, the model will dive before attaining its best flight speed. If you release the model faster than it wants to fly, it will stall and then dive before it starts flying. If the launch attitude is too much nose down, the glider will dive for a while at a speed higher than its normal flight. If the glider is launched too much nose up, it will stall before reaching its normal flight. Once the proper hand-launch technique is mastered, timed flights from hand-gliding the model can be used to judge the optimum trim of the glider. The student may notice that the glider's trim may change as the flight circle diameter is changed. The explanation for this is that as the circle gets smaller, the amount of lift generated by the wing decreases. (The inside wing is flying slower than the outside wing and generates less lift.)

There are three required elements of the flight log: Height at launch, Mass at launch and Flight time. A fourth element of the student's choosing is also required. Suggestions for this fourth element are: Flight circle diameter, Transition loss (height lost before smooth flight is attained), Adjustment changes (rudder bending, center of gravity shifts), Pilot of the glider, and Flight Description (stall, dive, hit the wall, hit the basketball backboard, etc).

Design your own glider

Once the student has gained familiarity with the construction and flying of this glider, it may happen that he/she wants to make some improvements. There are some design parameters inherent in this glider to which attention must be paid. The first rule is to keep it light... chose materials wisely and reduce the total number of parts. Each weighs up a little until the expected enhancements are countered by too much overall mass. For example, a better airfoil might improve the lift generated by the wing, but the extra curved ribs necessary to form a better airfoil will add significant mass. Pay close attention to the amount of adhesive used. The mass of adhesives to build a model can be a significant contribution to its overall weight, that's why the contact cement used for attaching the wood to the covering plastic is thinned with water. The second rule is to pay keep a slight angular difference between the wing and stabilizer. Gliders that have a 0-0 setting between wing and stabilizer tend not to recover (make a transition) from the initial launch resulting in a severe dive to the floor. The third rule is to keep a reasonable distance between the wing and stabilizer. The effectiveness of the stabilizer is increased as both its surface area and distance from the wing increases. The forth rule, if your glider is designed to come apart for storage and carrying in a box, is to make sure that it goes back together so that none of the alignments are changed. Very small changes in alignment can make dramatic differences in the glider's performance. The last rule is to plan your measurements so the size of the glider does not exceed specifications for the event. Make sure that the wing and stabilizer dimensions are safely less than the maximum allowed. For example, if you draw a plan with a 10.0 cm wing chord, it is very difficult to assure that no parts of the wing will exceed that dimension...better to plan for 9.5 cm. Even a very small deviation in excess of the 10 cm chord will cause disqualification.

One of the most important considerations for designing your own glider has nothing to do with the construction of the glider. You must have a box big enough for carrying the glider. The best boxes have removable tops. Flapping tops in the wind will not protect your glider from damage. Cardboard is a suitable material for a box. You can obtain large cardboard boxes and cut them to a pattern for the size you need. Use the Weldwood contact cement undiluted to glue the cardboard tabs together.

Sources of information, glider kits and exotic materials (super light coverings) can be found in links associated with two websites: Freeflight.org and IndoorDuration.com. If you have questions you may contact me at cmarkf1@aol.com. If you wonder where the name Kisloon came from, it is a combination of a well-known acronym in engineering: Keep It Simple and the suffix of the word Balloon.

Have fun!

Related Links

Freeflight.org

IndoorDuration.com